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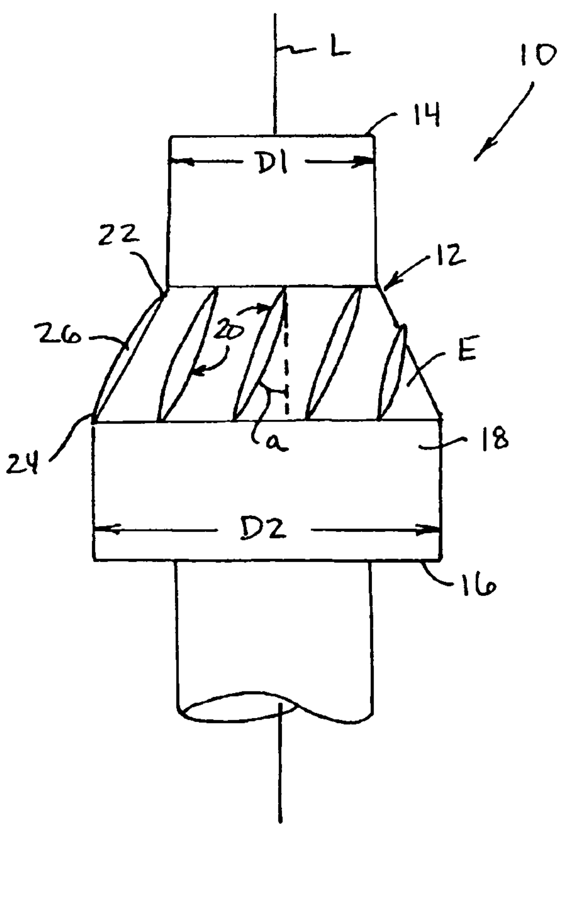
(54) Title: ROTATING MANDREL FOR EXPANDABLE TUBULAR CASING



(57) Abstract: An expansion mandrel for expanding tubular casing includes a tapered expansion portion having expansion segments which are angularly disposed on an external surface of the mandrel. The segments reduce friction and cause the mandrel to rotate in response to the mandrel being moved through the casing during expansion of the casing.

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ROTATING MANDREL FOR EXPANDABLE TUBULAR CASING

Cross Reference To Related Applications

[001] The present application claims the benefit of the filing dates of (1) U.S. provisional patent application serial no. 60/412,187, attorney docket no 25791.128, filed on 9/20/2002, the disclosure of which is incorporated herein by reference.

[002] The present application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent no. 6,328,113, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no. 60/3318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (29) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (30) U.S. utility patent

application serial no. 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001, (31) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001, (32) U.S. provisional patent application serial no. 60/346,309, attorney docket no 25791.92, filed on 1/7/2002, (33) U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/2002, (34) U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/2002, (35) U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/2002, (36) U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002, (37) U.S. provisional patent application serial no. 60/394,703, attorney docket no. 25791.90, filed on 6/26/2002, (38) U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/2002, (39) U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/2002, (40) U.S. provisional patent application serial no, 60/405,610, attorney docket no. 25791.119, filed on 8/23/2002, (41) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/2002, (43) U.S. provisional patent application serial no. 60412,653, attorney docket no. 25791.118, filed on 9/20/2002, (44) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/2002, (45) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/2002, and (46) U.S. provisional patent application serial no. 60/412,371, attorney docket no. 25791.129, filed on 9/20/2002, the disclosures of which are incorporated herein by reference.

Background of the Invention

[003] The present invention relates generally to tubular steel well casing and more particularly to an expansion mandrel which reduces stress during expansion of the casing.

[004] Solid tubular casing of substantial length is used as a borehole liner in downhole drilling. The casing is comprised of end-to-end interconnected segments of steel tubing to protect against possible collapse of the borehole and to optimize well flow. The tubing often reaches substantial depths and endures substantial pressures.

[005] It is present practice to expand the steel tubing downhole by using a mandrel. This is a cold-working process which presents substantial mechanical challenges. This technology is known as solid expandable tubular (SET) technology. This cold-working process deforms the steel without any additional heat beyond what is present in the downhole environment.

[006] An expansion cone, or mandrel, is used to permanently mechanically deform the pipe. The cone is moved through the tubing by a differential hydraulic pressure across the cone itself, and/or by a direct mechanical pull or push force. The differential pressure is pumped through an inner-string connected to the cone, and the mechanical force is applied by either raising or lowering the inner string.

[007] Progress of the cone through the tubing deforms the steel beyond its elastic limit into the plastic region, while keeping stresses below ultimate yield. Expansions greater than 20%, based on pipe ID, have been accomplished. However, most applications using 4 1/4 - 13 3/8 inch tubing have required expansions less than 20%.

[008] At the bottom of the SET system is a canister, known as the "launcher," that contains the expansion cone. The launcher is constructed of thin-wall, high-strength steel that has a thinner wall thickness than the expandable casing. Because the launcher has a thinner wall and its OD is the same as the drift of the previous casing string, it can be tripped into the hole through the previous casing string.

[009] The difference in wall thickness of the launcher and the elastomer-coated hanger joint(s) allows the expanding pipe to be sealed, or "clad," to the previous casing string. The expanded pipe ends up with an OD that is greater than the OD of the launcher, due to its greater wall thickness. The ID of the pipe expands to the same ID of the launcher, which is a function of expansion cone OD.

[0010] Contact between cylindrical mandrel and pipe ID during expansion leads to significant forces due to friction. It would be beneficial to provide a mandrel which could reduce friction during the expansion process.

Summary Of The Invention

[0011] One embodiment accordingly, provides an apparatus and method for reducing such friction. To this end, the apparatus includes an expansion mandrel having a longitudinal axis, a first end, a second end and a tapered portion between the first and second ends. A plurality of expansion segments are provided on the expansion portion. Each segment is angularly disposed relative to the longitudinal axis.

[0012] A principle advantage of this embodiment is that the angularly disposed segments reduce contact with the ID of the casing. The angular relationship of the segments cause the mandrel to move in a helical path within the casing ID thereby establishing a self-feeding characteristic in the mandrel.

Brief Description of the Drawings

[0013] Fig. 1 is a side view illustrating an embodiment of an expansion mandrel.

[0014] Fig. 2A is a partial side view illustrating an embodiment of a rotatable segment.

[0015] Figs. 2 – 5 are partial side views illustrating embodiments of expansion segment profiles.

[0016] Fig. 6 is a partial side view illustrating an embodiment of an expansion segment including friction lowering buttons.

[0017] Figs. 7A – C are side views illustrating an embodiment of an expansion mandrel and a resulting expanded casing.

Detailed Description of the Illustrative Embodiments

[0018] An expansion mandrel is generally designated 10 in Fig. 1, and includes a main body 12 having a longitudinal axis L which extends between a first end 14 and a second end 16 of the main

body 12. An external surface 18 of body 12 has a first diameter D1 at first end 14, and a second diameter D2, larger than D1, at second end 16, interconnected by a tapered expansion portion E. The first end 14 of body 12 is a leading end being of the smaller diameter D1, and the second end 16 is a trailing end being of the larger diameter D2.

[0019] A plurality of expansion segments 20 are provided on the expansion portion E. Each segment 20 is elongated and has an axis angularly disposed at an angle (a) from about 1° to about 3° with the axis L. A segment 20, Fig. 2A, may be an elongated, substantially oval shaped segment, inserted and rotatably seated in a pocket 19 formed in surface 18 of mandrel 10. In this manner, the segment 20 rotates in a direction D about its longitudinal axis L' independent of the mandrel 10 which moves in a spiral path through a steel casing 30, discussed below. Each segment may be machined onto surface 18, Fig. 2, so as to protrude therefrom. Also, each segment can be an insert, Fig. 3, having a first portion 20a imbedded in surface 18 and a second portion 20b protruding from surface 18. Each segment 20 has a leading end 22 disposed toward end 14, a trailing end 24 disposed toward end 16, and an intermediate portion 26 between ends 22 and 24. As illustrated in Figs. 2 and 3, ends 22 and 24 may be flush with surface 18, whereas intermediate portion 26 protrudes from surface 18. Alternatively, end 22 may be flush with surface 18, Fig. 4, and end 24, along with intermediate portion 26 may protrude from surface 18. In another embodiment, Fig. 5, both ends 22, 24 and intermediate portion 26 may protrude from surface 18. In a further embodiment, Fig. 6, a plurality of friction lowering buttons 28 may protrude from each segment 20. Buttons 28 may be machined onto or embedded in segment 20 and may be formed of a metal or diamond material.

[0020] Mandrel 10, Figs. 7A, 7B and 7C, includes segments 20, and is used for expanding an elongated section of steel casing 30 defining an elongated passage 32 therein. Mandrel 10 is positioned, for example in a position A, Fig. 7A, and is axially moved through the passage 32 to an exemplary position B, Fig. 7B, and position C, Fig. 7C, to expand passage 32 from an original diameter 0 to an expanded final diameter F. Due to the angular disposition of segments 20, Fig. 1, mandrel 10 rotates during movement in a helix as indicated by a direction of rotation at arrow R, Fig. 7C.

[0021] It should be understood that the angle (a) may be varied as well as the geometry and material of each segment 20. Also, each segment 20 may extend over the entire length of the mandrel 10 or only over a portion thereof. In any case, friction forces are greatly reduced by the reduced surface area of contact between the mandrel 10 and the casing 30.

[0022] Although illustrative embodiments have been shown and described, a wide range of modification, change and substitution is contemplated in the foregoing disclosure and in some instances, some features of the embodiments may be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the embodiments disclosed herein.

Claims

1. An apparatus for expanding tubular casing comprising:

   an expansion mandrel having a longitudinal axis, a first end, a second end and a tapered expansion portion between the first and second ends; and

   a plurality of expansion segments, on the expansion portion, each segment being angularly disposed relative to the longitudinal axis.

2. The apparatus as defined in claim 1 wherein the angular disposition of each segment is from about 1° to about 3°.

3. The apparatus as defined in claim 1 wherein each segment is machined to protrude from an external surface of the mandrel.

4. The apparatus as defined in claim 1 wherein each segment has a first portion seated in an external surface of the mandrel and a second portion protruding from the external surface.

5. The apparatus as defined in claim 4 wherein each segment is rotatably seated in a pocket formed in the external surface.

6. The apparatus as defined in claim 1 wherein each segment has a leading end disposed toward the first end of the mandrel and a trailing end disposed toward the second end of the mandrel.

7. The apparatus as defined in claim 6 wherein the leading end is flush with an external surface of the mandrel and the trailing end is flush with the external surface of the mandrel, and wherein an intermediate portion between the leading and trailing ends protrudes from the external surface.

8. The apparatus as defined in claim 6 wherein the leading end is flush with an external surface of the mandrel and the trailing end protrudes from the external surface.

9. The apparatus as defined in claim 6 wherein the leading and trailing ends protrude from an external surface of the mandrel.

10. The apparatus as defined in claim 1 wherein each segment includes a plurality of friction lowering buttons extending therefrom.

11. The apparatus as defined in claim 10 wherein the friction lowering buttons are formed of a diamond material.

12. The apparatus as defined in claim 10 wherein the friction lowering buttons are formed of a metallic material.

13. A method for expanding tubular casing comprising:

    providing an elongated section of steel casing having a longitudinal axis, an outer circumferential surface and an inner circumferential surface defining an elongated axial passage through the tubing;

positioning an expansion mandrel for movement through the passage for radially expanding the tubing, the expansion mandrel having a first end, a second end and a tapered expansion portion between the first and second ends;

providing a plurality of expansion segments on the expansion portion, each segment being angularly disposed relative to the longitudinal axis; and

moving the mandrel through the axial passage whereby the segments rotate the mandrel during expansion of the casing.

14. The method as defined in claim 13 further comprising:

orienting each segment at an angle of from about 1° to about 3°.

15. The method as defined in claim 13 further comprising:

forming each segment to protrude from an external surface of the mandrel.

16. The method as defined in claim 15 further comprising:

rotatably seating each segment in a respective pocket formed in the external surface.

17. The method as defined in claim 13 further comprising:

providing each segment with a leading end disposed toward the first end of the mandrel and a trailing end disposed toward the second end of the mandrel.

18. The method as defined in claim 17 further comprising:

forming the leading end flush with an external surface of the mandrel and forming the trailing end to protrude from the external surface.

19. The method as defined in claim 17 further comprising:

forming the leading and trailing ends flush with an external surface of the mandrel and forming an intermediate portion of each segment to protrude from the external surface.

20. The method as defined in claim 17 further comprising:

forming the leading and trailing ends to protrude from an external surface of the mandrel.

21. The method as defined in claim 17 further comprising:

providing each segment to include a plurality of low friction buttons extending therefrom.

22. A method for expanding tubular casing comprising:

providing an elongated section of steel casing having a longitudinal axis, an outer circumferential surface and an inner circumferential surface defining an elongated axial passage through the tubing;

positioning an expansion mandrel for movement through the passage for radially expanding the tubing, the expansion mandrel having a first end, a second end and a tapered expansion portion between the first and second ends;

providing a means on the mandrel for reducing friction and for causing the mandrel to rotate in response to the mandrel being moved along the inner circumferential surface of the casing; and

moving the mandrel through the axial passage for expanding the casing.

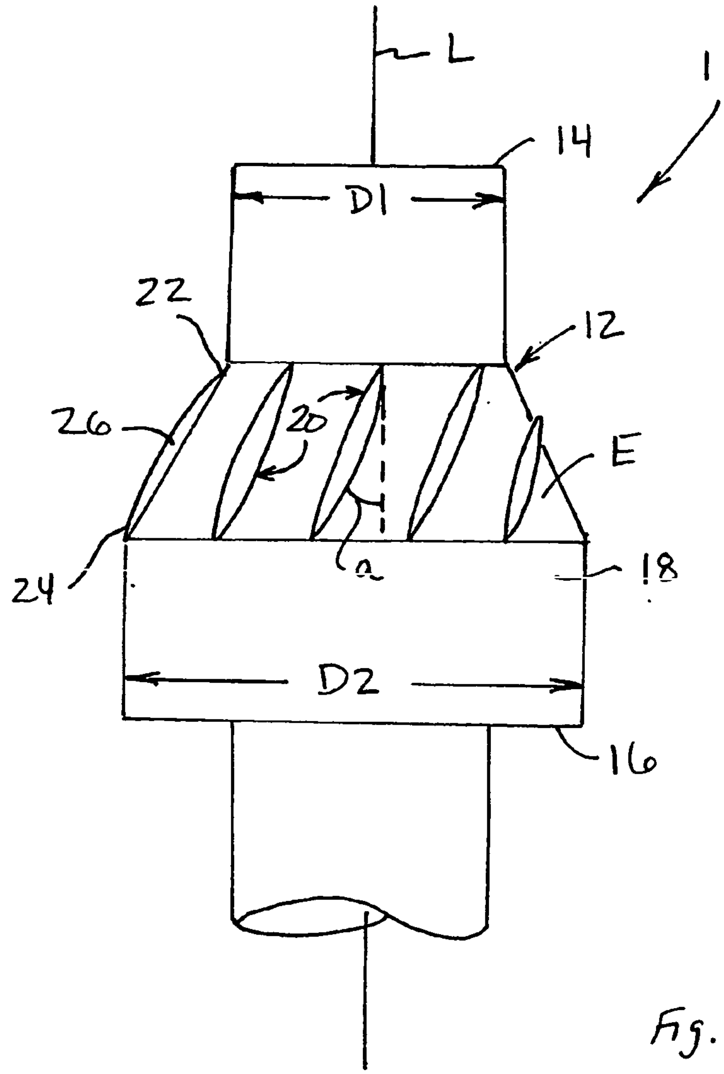

Fig. 1

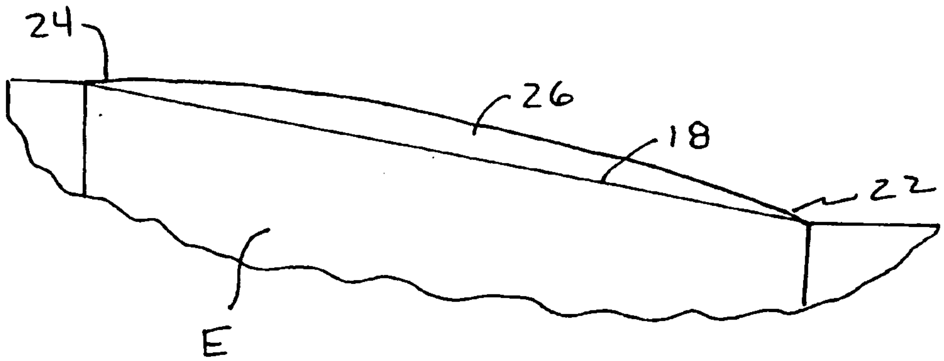

Fig.2

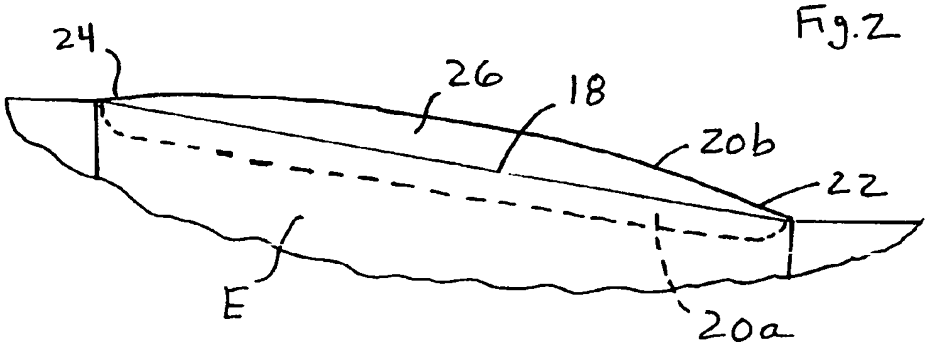

Fig.3

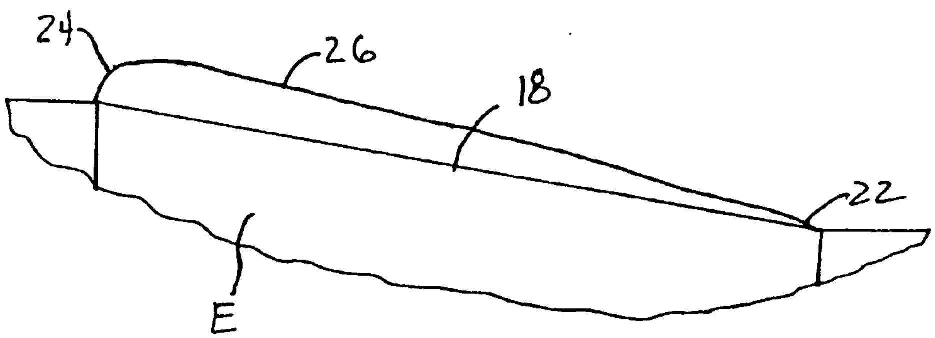

Fig.4

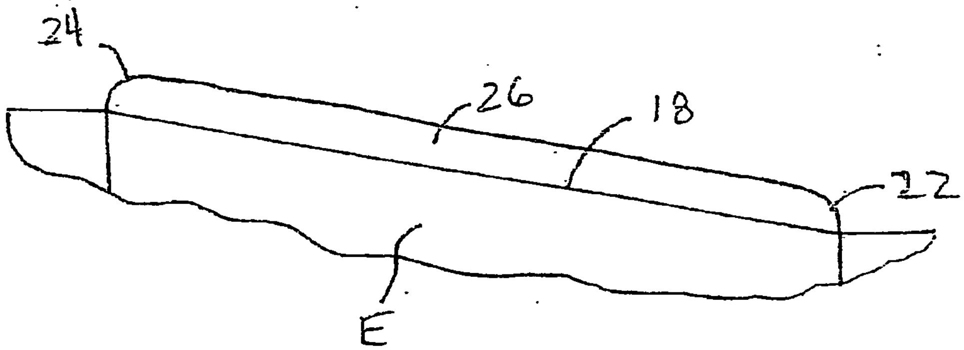

Fig.5

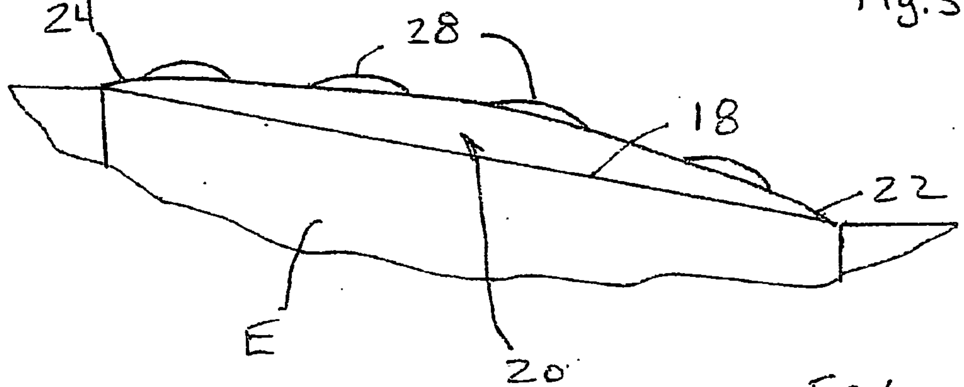

Fig.6

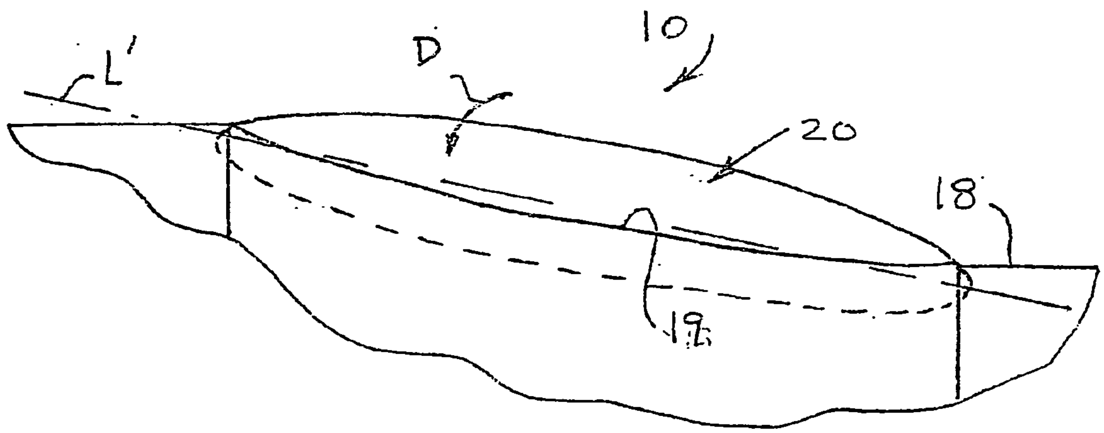

Fig.2A

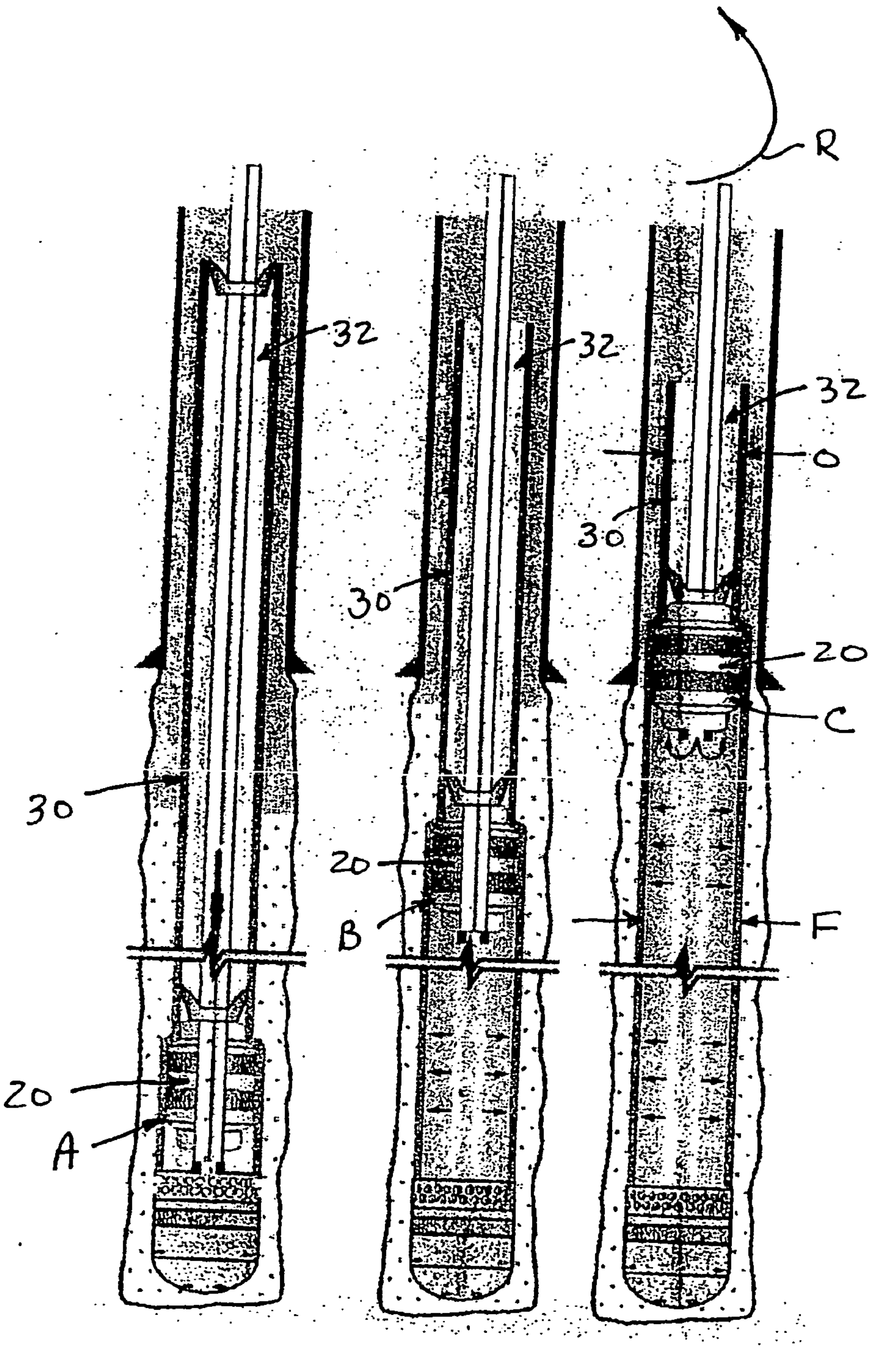

Fig.7A Fig.7B Fig.7C